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The Italian science and cooperation at the shadow of K2

Risk assessment through landslide susceptibility map

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INTRODUCTION

The aim of the project is the identification of the **landslide-prone areas inside the borders of the Central Karakorum National Park (CKNP) in order to a have a first landslide inventory in the area**.

A qualitative risk assessment is possible where a detailed landslide inventory map and a map of structures (houses, buildings, etc.) and infrastructure (roads, railways, lifelines, etc.) at risk are available in GIS form (Guzzetti, 2002).

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What could we do for CKNP territory?

The IFFI italian project

Italian landslide inventory

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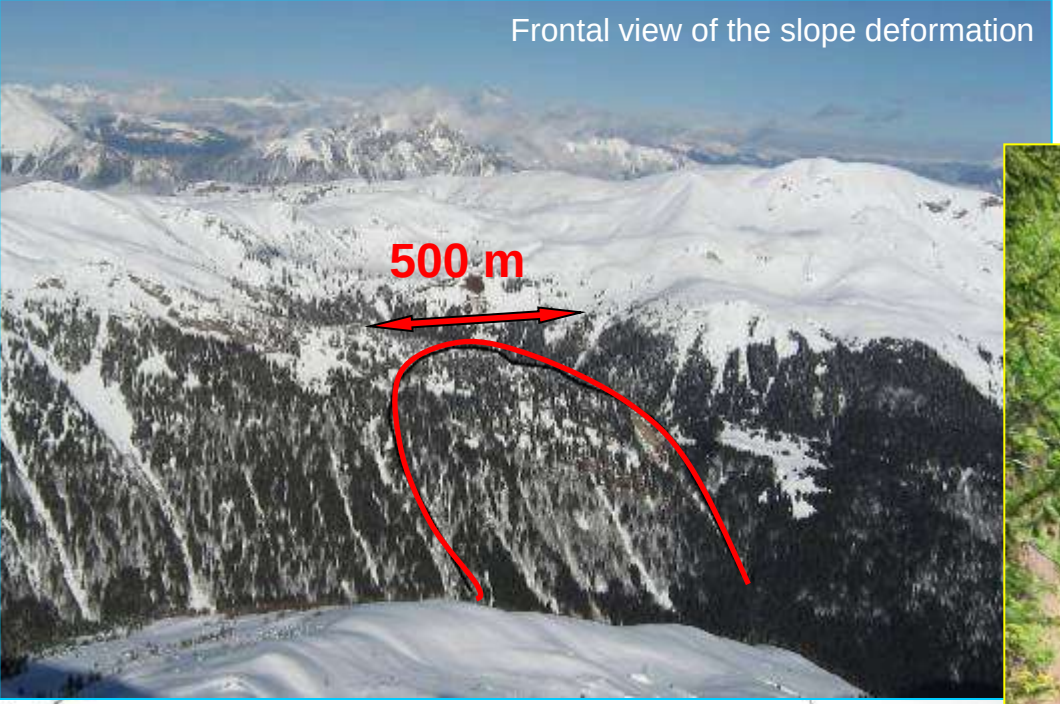
The studied phenomenon



The **Khaltaro** landslide is a sliding movement of detritical material over a rocky dipping surface. The length of the crown is approximately 200m, the height of the main scarp is about 4 m (**A** and **B**), all around the crown there are tension cracks 1,5m wide. Walking on the main body (**C**), it is possible to identify several longitudinal tension cracks with a gap of 10 to 15cm. This landslide is particular because there is a village with houses and fields at the toe of the slope, on the right side of the river. The phenomenon is moving towards the settlement. Witnesses reported that the movement began in 2009. Now the Pakistani government put up some tents (red circle) in a safer place (**C**), close to the village in order to avoid a possible disaster; **C:** Researchers on the main body of the landslide. On the background the blue tents belonging to the Civil Defence.

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Landslide recognition

Landslide outline

Landslide map

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An italian example

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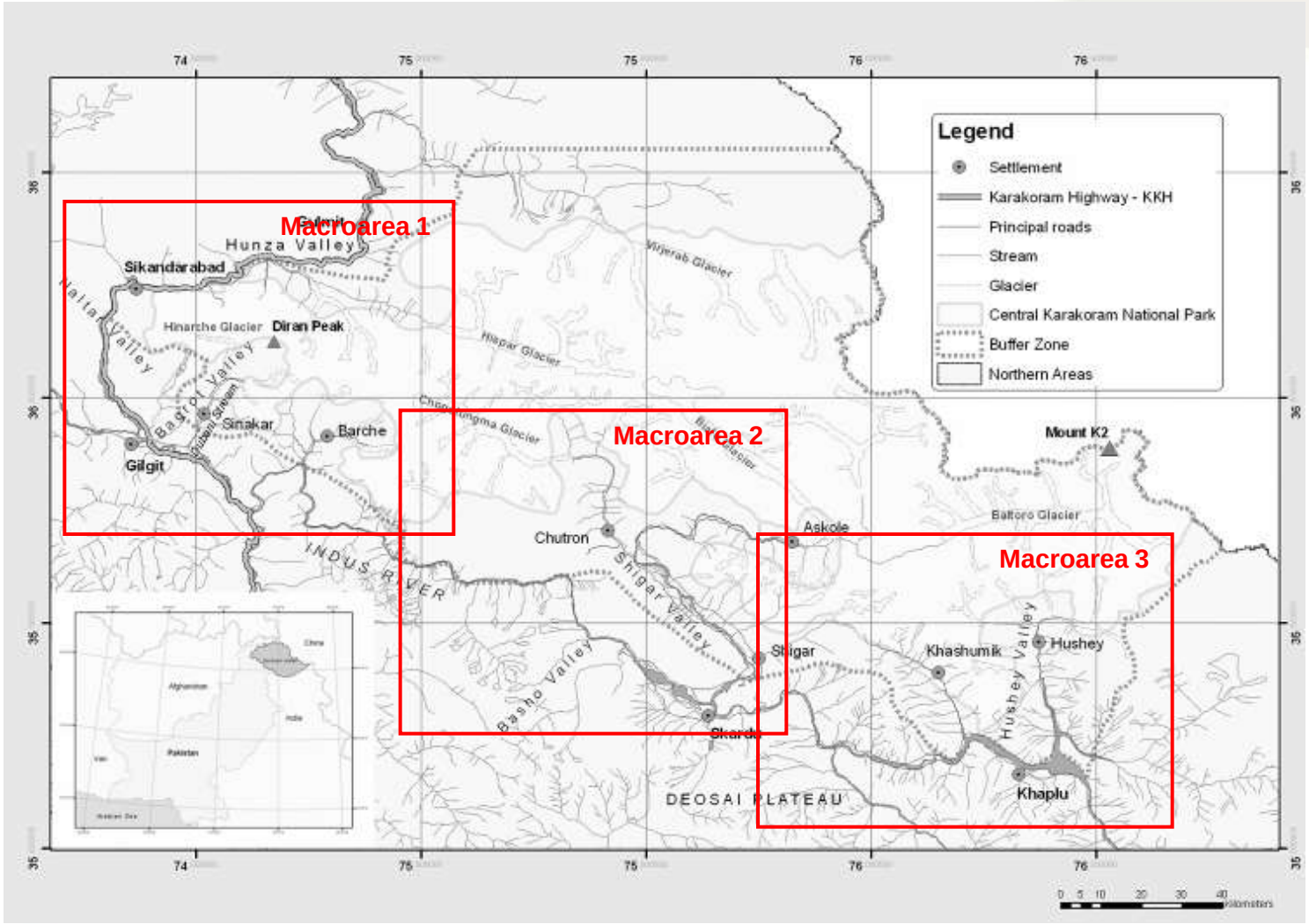
AREAS OF INTEREST



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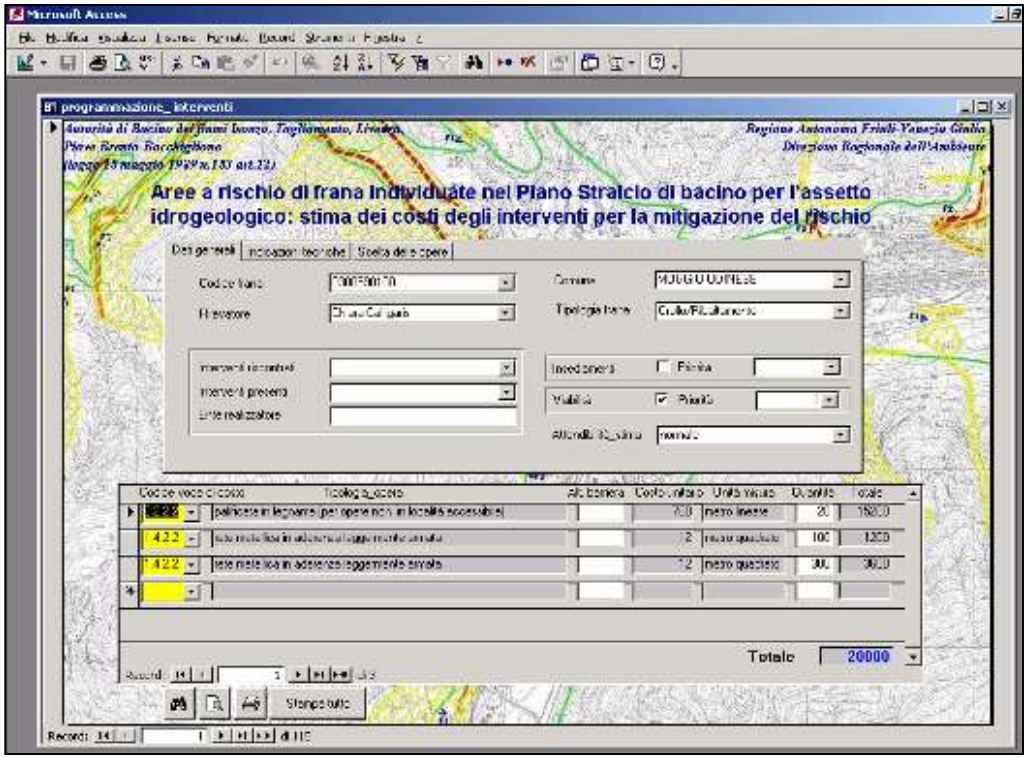
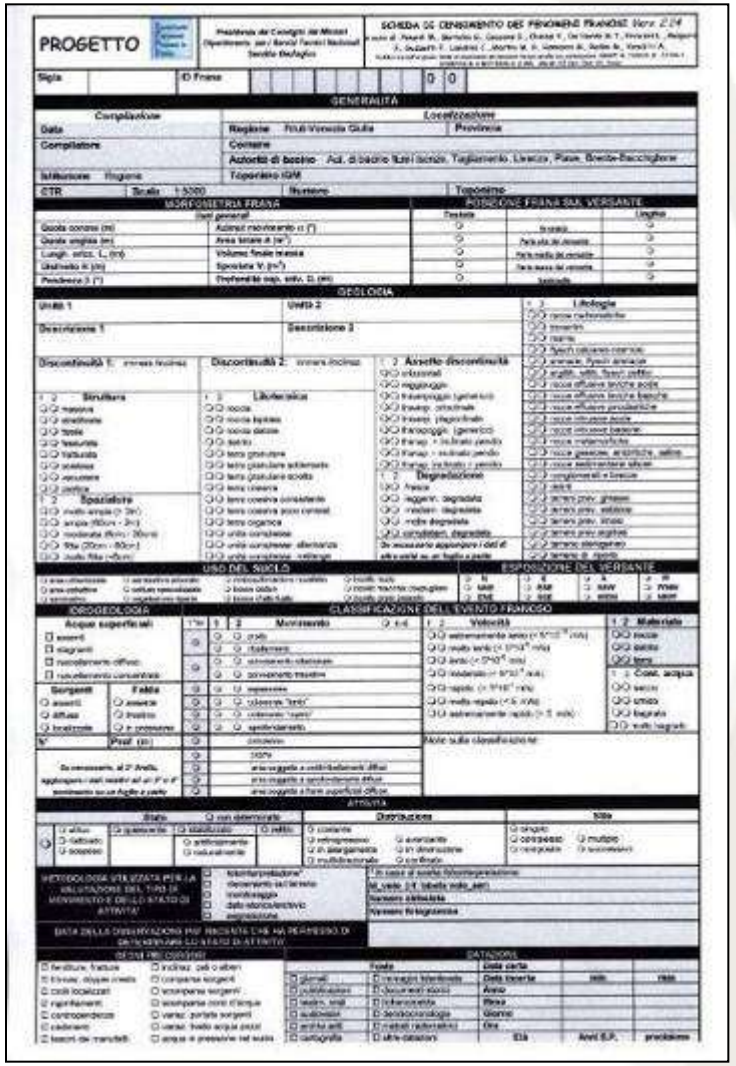
Methodological Approach

At present, after the surveys realized in 2011 and 2012, **more than 100 landslides** were recognized in the CKNP. For every landslide a report was made concerning all the morphological, geological and geotechnical available parameters. These information were added in a database similar to the one available for the **italian IFFI project**.



Report and one of the DB mask prepared for the IFFI project.



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Field survey

Landslides Identification Form

Date: _____ No: _____

Surveyor: (Name, Surname, Organization)_____

Village/Area/Valley: _____

Position - using coordinate system **WGS 84 – UTM 43 N**
(I.E.: 36°25'58"N 74°35'28"E; or kilometric coordinates).
Coord X:_____ Coord Y:_____

Z (m a.s.l.):_____

Landslide is: Active, reactivated, quiescent, old landslide

Vegetation cover: bare soil, meadow, shrub, closed forest

Land use: cultivated areas, wood, uncultivated, artificial surfaces (built areas, roads), pasture

Infrastructures involved: road, house, bridge, track

Previous events, damages, people involved

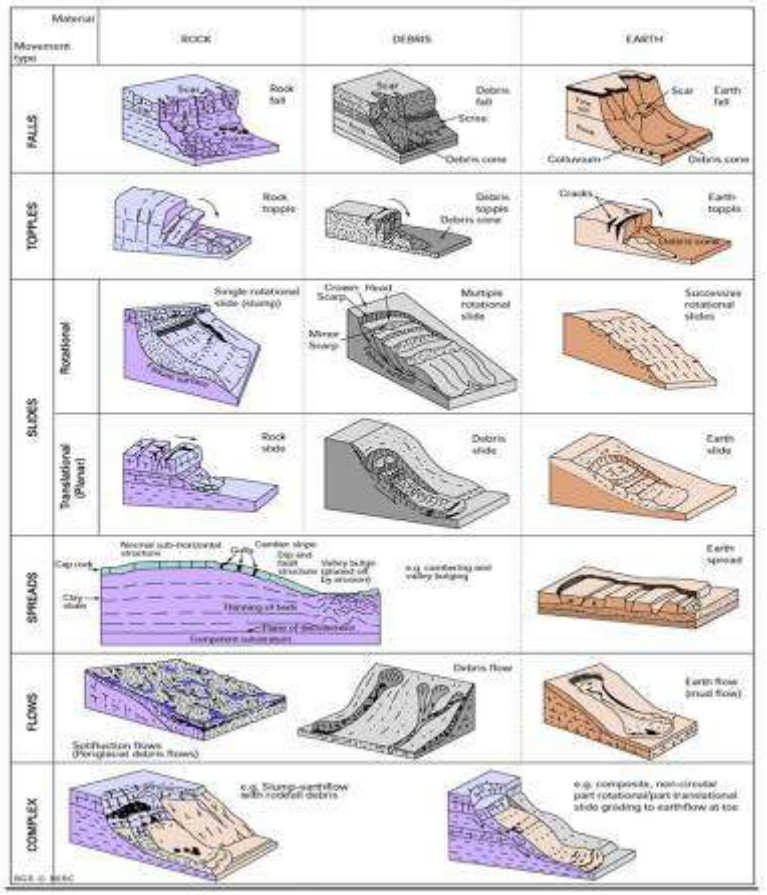
Notes:

Pictures (one or more):

1

Data is collected for academic purpose. Please give accurate information regarding landslide event. The Information may be published.

Types of landslides (circle the recognized type)



2

Source: Classification of type of landslip (modified after Varnes, 1978 and DoE, 1990).

Landslides represent a constant danger along the roads accessing to the CKNP from every direction.
On the right an example in the Bagrot Valley.
In red the active fan.

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“Fresh” landslide **on the way to Khaltaro**. Repeated rock falls created a wide and heterogeneous deposit. The grain size is variable. The return time of the event is several times a year. Red arrow indicates the movement direction over a slope angle of about 45°.

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Hakuchar – Hunza Valley (Pakistan)

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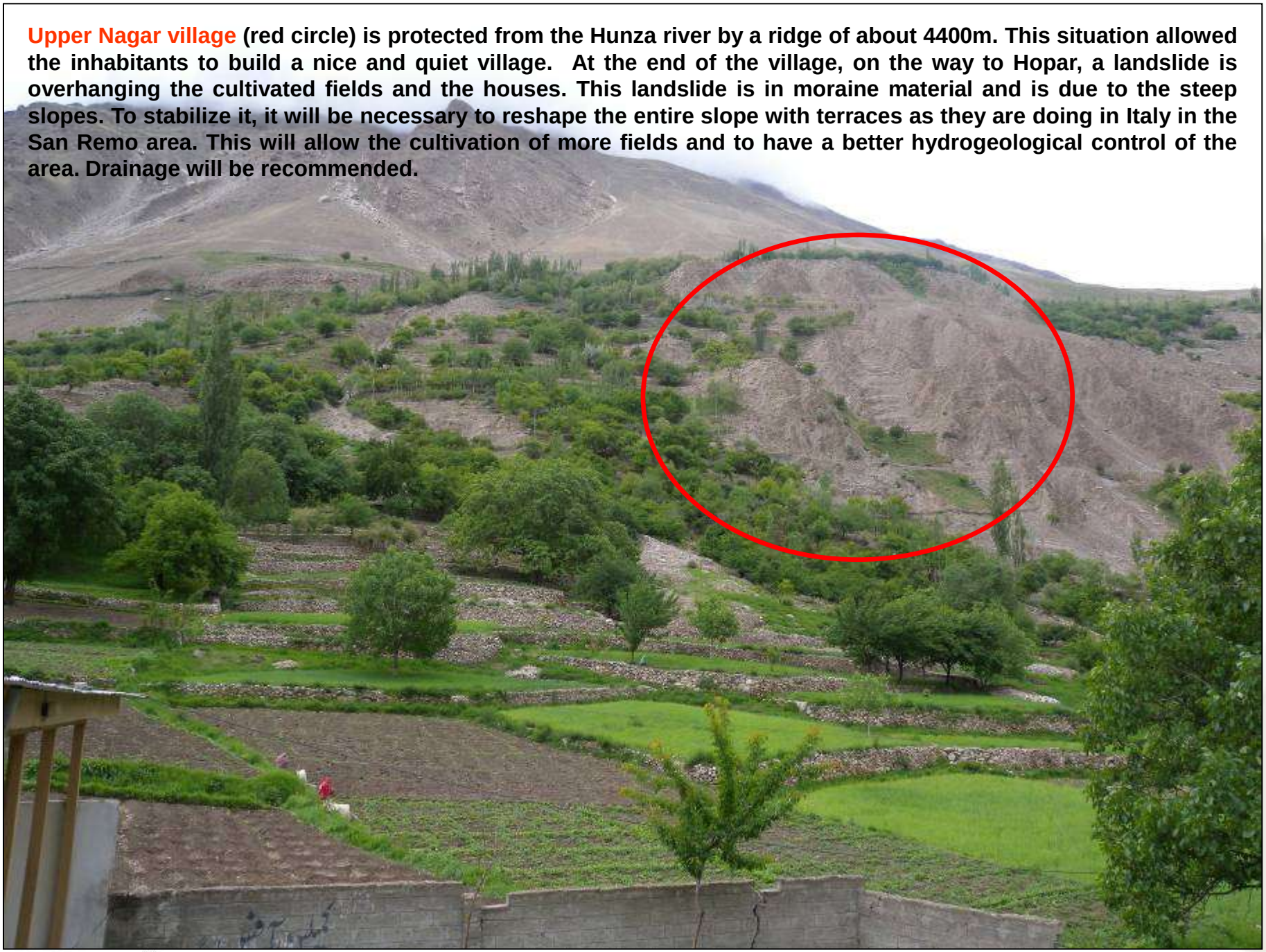
On the way to Hopar glacier: the old road realized in a dangerous place. Fluvial banks erosion is one of the main triggering factors of the landslides in these narrow valleys.

Outlined by a red line, the available detritical material, red arrows indicate the sliding direction. In pale blue the fluvial erosion.



Upper Nagar village (red circle) is protected from the Hunza river by a ridge of about 4400m. This situation allowed the inhabitants to build a nice and quiet village. At the end of the village, on the way to Hopar, a landslide is overhanging the cultivated fields and the houses. This landslide is in moraine material and is due to the steep slopes. To stabilize it, it will be necessary to reshape the entire slope with terraces as they are doing in Italy in the San Remo area. This will allow the cultivation of more fields and to have a better hydrogeological control of the area. Drainage will be recommended.

Road to Hispar glacier: landslides are affecting the road constantly.

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Terraces banks are one of the most instable slopes due to their steepness and the nature of the involved loose or poorly cemented material.

Scarps are always affected by landslides all over the year but especially during the monsoon seasons

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Hopar glacier: the sides of a glacier valley are usually affected to landslides due to the decompression of the banks made by terraces.

Biafo glacier area: an opening fracture

Rock fall at the beginning of the track to Concordia (K2 Base Camp).

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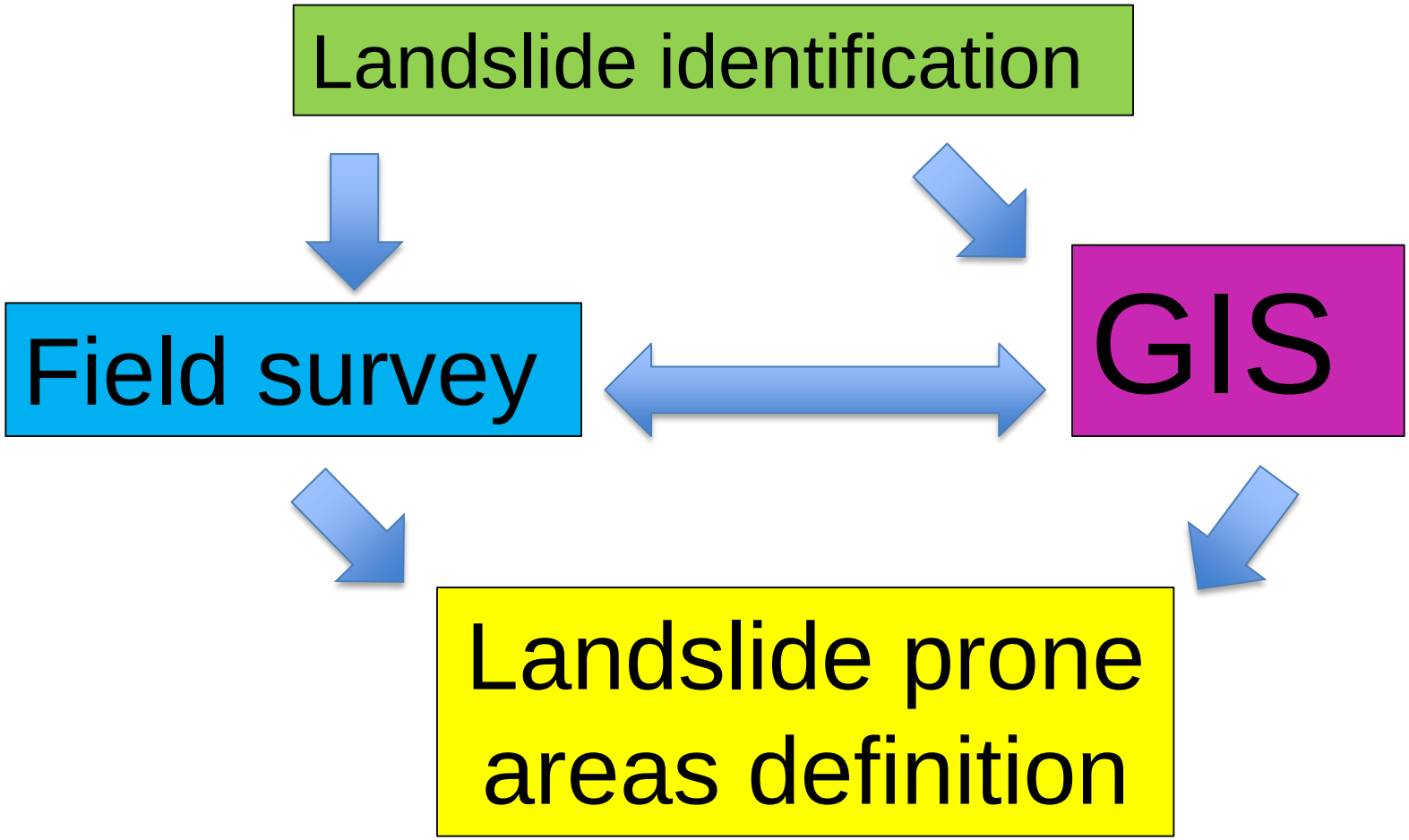
Methodological Approach



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Landslide susceptibility map through the GIS tool

Overlay of different themes:

Geology

Tectonic lines (faults, trusts..)

Slope

Aspect

Curvature

Land cover

Land use

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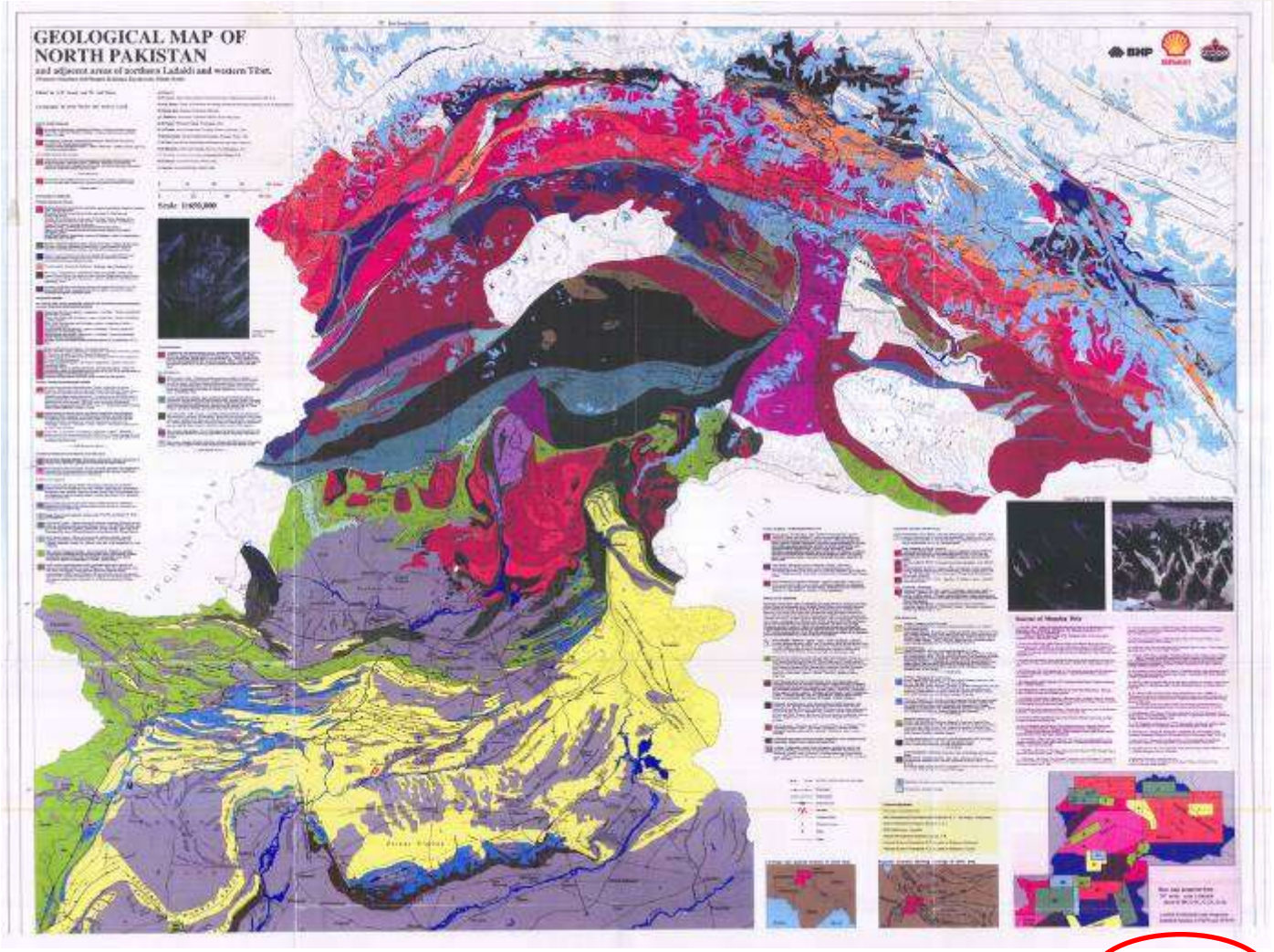
In Italy the working scale is 1:5.000



Searle and Asif, 1996-M.P. Searle, Khan Asif (Eds.), Geological map of North Pakistan, 1 : 650,000, lackwell, Oxford (1996)

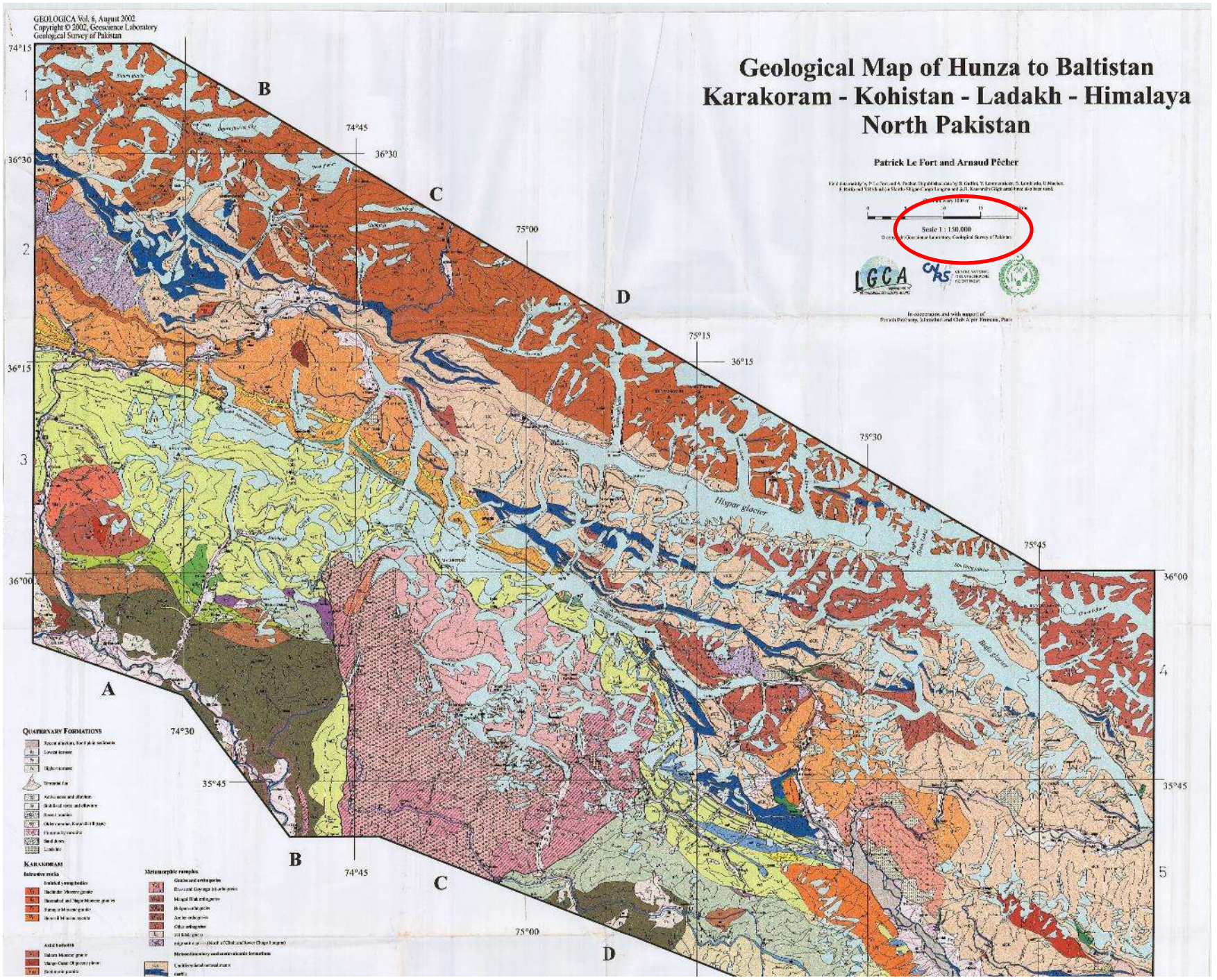
….so the working accuracy……

GEOLOGICA Vol. 6, August 2002

Geological Map of Hunza to Baltistan
Karakoram - Kohistan - Ladakh - Himalaya
North Pakistan

Patrick Le Fort and Arnaud Pêcher

Scale 1 : 150,000



The Bagrot valley area: an example

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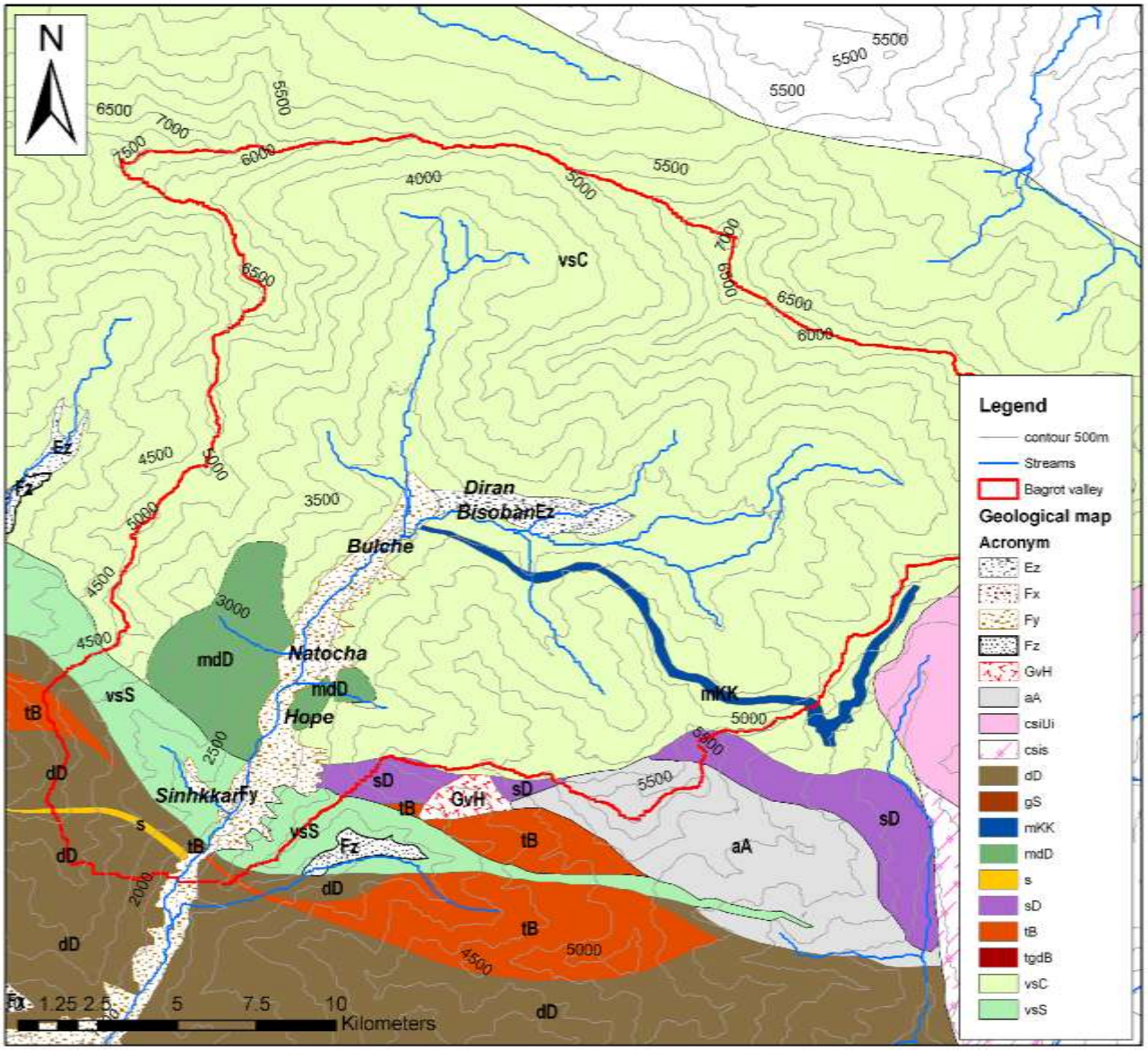

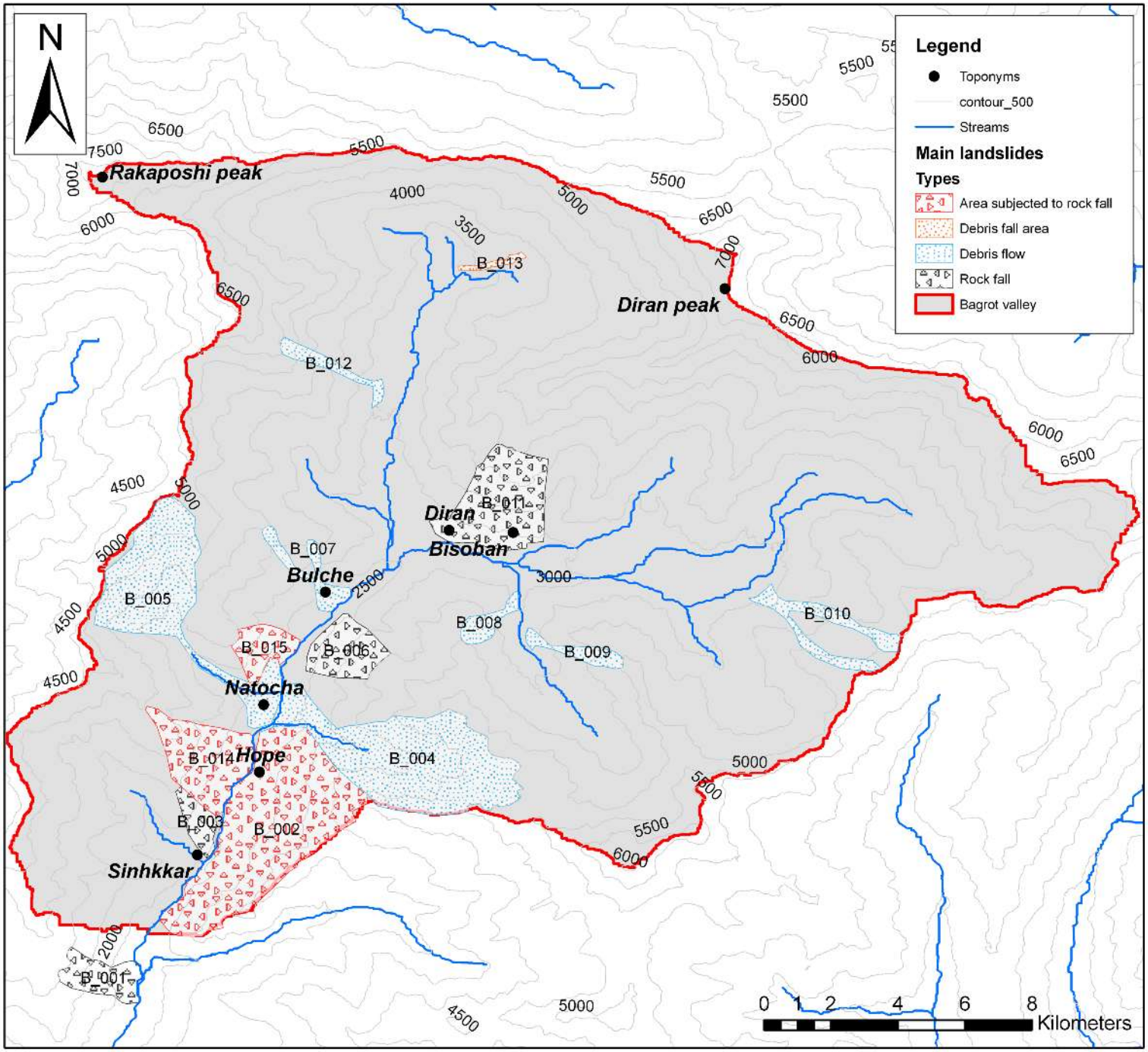

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SLOPE
ASPECT
CURVATURE

all derived from DEM and its relative accuracy

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In a risk assesment analysis are considered also themes as ice and land cover

these data were provided by the SEED partners

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According to **AHP** (Analitycal Hyerarchy Process) technique and PAIR-WISE comparison matrix

Factors and classes with the assigned relative ranks ranging from 1 to 9 in order of importance. Weights (0-9) were assigned to the classes: higher values indicate more influence towards landslide occurrence.

Factors	Classes	Ranks	Weights
Geology	Paragneisses (SKm)	1	4
	Andesite (Cv)		6
	Slates (Gm)		9
	Gabbrodiorite (KB)		6
	Permanent snow/ice cover		1
Fault buffer	0-250 m	1	9
	250-500m		6
	500-750m		3
	> 750		0
Slope	0° - 15°	2	1
	15° - 25°		3
	25° - 35°		5
	35° - 45°		7
	> 45°		9
Aspect	Flat	1	0
	North		1
	Northeast		4
	East		7
	Southeast		8
	South		9
	Southwest		6
	West		3
	Northwest		2

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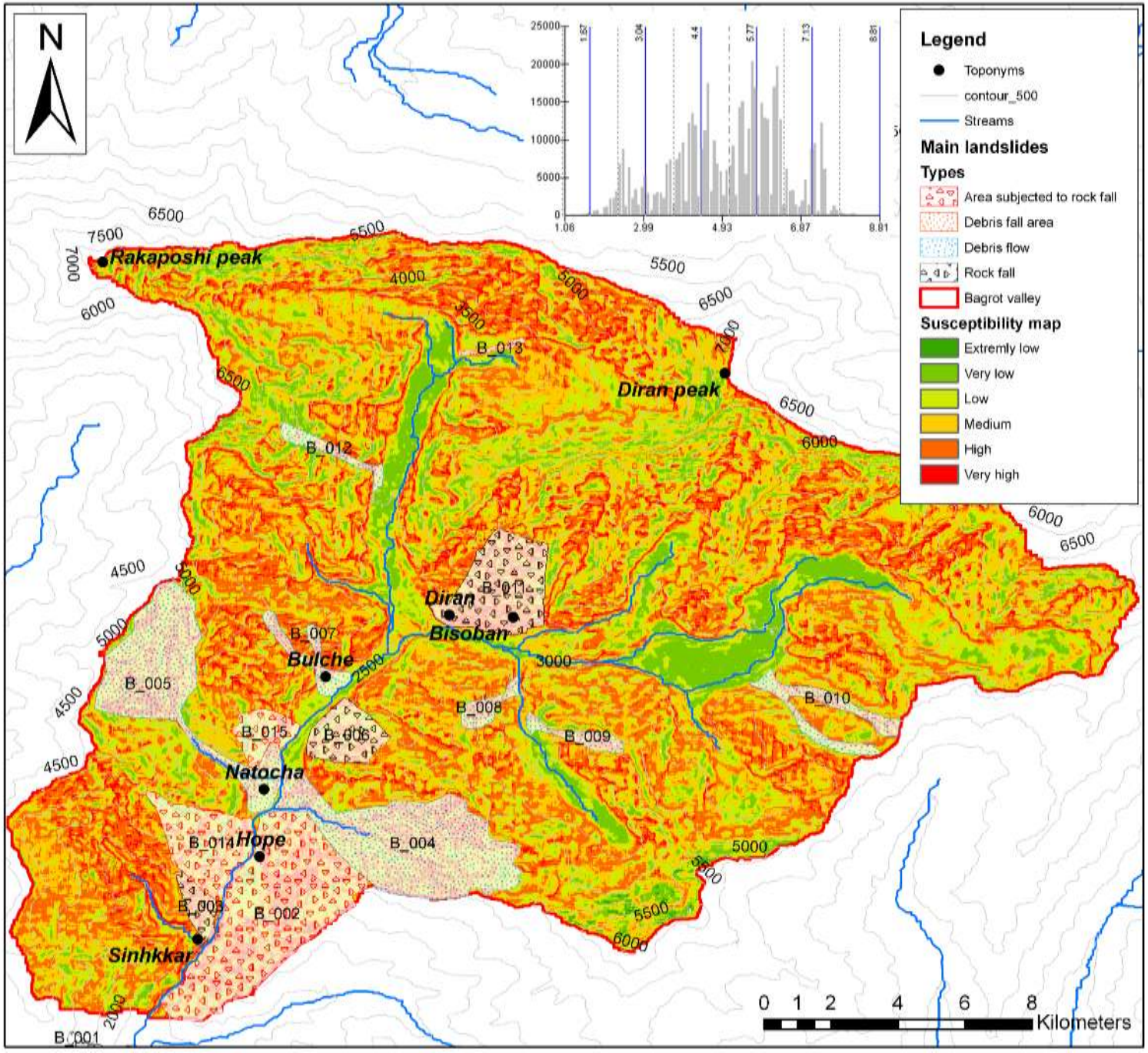
Thomas L. Saaty, *Multicriteria decision making - the analytic hierarchy process. Planning, priority setting, resource allocation* , RWS Publishing, Pittsburgh, 1988.



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Risk Assesment

Landslide risk evaluation aims to determine the "**expected degree of loss due to a landslide (specific risk) and the expected number of live lost, people injured, damage to property and disruption of economic activity (total risk)**" (Varnes et al., 1984; Guzzetti, 2002).

To define the risk is necessary to identify which are the element at risk. In the CKNP case, they are mainly represented by the tracks taking tourists to the peaks.
So the researchers' attention is focused on these frequented areas.

Jointed data will form the basic risk map on which decision makers could start to work.

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Results

- Three valleys were surveyed in 2011, 2 in 2012: Bagrot, Haramosh, Hopar, Chogolungma and Biafo and more than 100 main landslides were identified
- Data concerning lithological characteristics, land cover, tectonics, land use and glacier extension were collected
- The identified landslides were catalogued, and the main characteristics were defined
- A simple but complete landslide identification form was created and field tested
- A GeoDataBase was implemented
- A preliminary GIS investigation was realized
- Jointly with the GIS group, preliminary geological and tectonic maps of the CKNP area were prepared starting from a 1:650.000 and 1:150.000 scale studies
- A susceptibility map was produced


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Thank you
for attention
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